8. Soils

Effects from the Forest's management activities may individually or cumulatively result in significant changes to soil productivity. Even where change is not significant, effects or lack thereof provide insight into the effectiveness of or need for change in current Forest management practices. The extent to which the desired conditions and objectives are being met also helps determine presence of change, its significance, and the need for altering current Forest management practices.

Key Points

- Soils monitoring needs to include forest management activities other than just vegetation treatments to adequately assess how well objectives and desired conditions of the Forest Plan are being met.
- In the future, more quantitative soils monitoring will be necessary to assess the effects of forest management activities with greater confidence.
- Results from both Forest and MDNR monitoring show that forest management activities were generally in high compliance with BMPs. Failures were found primarily with rehabilitation of log landings and temporary roads and coarse woody retention; however visual signs of soil disturbance were not evident.
- The lack of observable soil impairment in monitored vegetation treatment areas may be largely due to effective implementation of Forest Plan Standards and Guidelines and BMPs. Where issues were found they were small in scale and appeared to have little impact on soil productivity.
- It is highly likely that earthworms are present across the Forest. Current and past observed impacts illustrate the need for a more detailed inventory of the infestation and development of tools to reduce further risk of spread.
- There's debate within the soil science community whether complete slash retention on dry, poor-nutrient, sandy soils is necessary (G-WS-10 specifies "Retaining or returning fine slash (<3inch diameter) well distributed over the site.." FP, p. 2-15). Until more definitive research has been published on the matter, the Forest should continue to follow Forest Plan Standards, Guidelines, and BMPs for slash retention and biomass removal.
- Soils management on the Forest will likely change to be both proactive and responsive to future climate change.

Monitoring Question

Are the effects of forest management, including prescriptions, resulting in significant changes to productivity of the land?

Results

Focused Soil Quality Monitoring

One scarification treatment and three of the eight harvest units monitored in 2006 and 2009, had visual signs of soil compaction in the form of rutting. Repeated passes of heavy equipment on saturated, unfrozen soils was most likely the cause. Rutting was shallow and isolated to small portions of the treatment areas, thus it appeared to have little impact on soil productivity. The area extent of timber sale infrastructure met recommended BMPs in all units monitored (MFRC 2005). Temporary roads and log landings were less than 3% of the total harvest area and skid trails represented no more than 10-15% of the harvest area (USDA 2006 and 2009),

All fine slash less than 3 inches was retained and well distributed across one of the two harvest units monitored for nutrients in 2007. Some of the fine slash was removed in the other unit for biomass harvest. Fine slash remaining on the site after biomass harvest was not evenly distributed. The effects of slash removal and distribution on site productivity was not determined (USDA 2007), but management practices were found to be inconsistent with Forest Plan guidelines based on current soil conditions (USDA 2004a, p. 2-16).

Two commercial thinning treatments out of the seven harvest units monitored in 2008 had visual signs of erosion. Rill erosion was present at a log landing in one harvest unit and soil deposition was found within the general harvest area of the other. Erosion was also present in the scarification treatment area, particularly where furrows were dug perpendicular to steep slopes (USDA 2008), a practice that should have been avoided according to Forest Plan standards and guidelines (USDA 2004, p. 2-16) and BMPs (MFRC 2005). In all treatment areas, instances of erosion were small, isolated, and soil movement was minimal, primarily due to heavy slash retention. There appeared to be little impact to soil productivity (USDA 2008).

Interdisciplinary Forest Plan Monitoring

A few trends stood out after reviewing the results from interdisciplinary monitoring of harvest activities from 2006 to 2009.

- All harvest activities occurred within required seasonal restrictions. The frozen harvest restriction for one harvest unit was waived by a FS soil scientist due to abnormally dry soil conditions following a prolonged drought. Little to no visual sign of compaction or rutting was present as a result of the change.
- In general, there was little to no visual signs of compaction or erosion present in the harvest areas outside of the log landings and skid trails. Compliance with seasonal harvest restrictions, avoidance of wet spots or steep slopes, and frequent use of slash mats were all likely factors.
- The area extent of timber sale infrastructure, in all harvest units, was consistent with BMPs. The area occupied by temporary roads and log landings was less than 3% of the total harvest area in all units. Skid trails occupied less than 10-15% of the total harvest area in all units as well. Use of preexisting infrastructure has been and continues to be a focal point during timber sale design.
- Slash retention was adequate in all harvest areas except for the coarse woody component. Slash retention of the 3 inch or less size classes, met Forest Plan standards, guidelines (USDA 2004, p. 2-16) and BMPs (MFRC 2005) in all harvest units. Sites lacking coarse

woody debris appeared to lack sufficient material even prior to harvest (USDA 2006-2009).

Overall, implementation of Forest Plan standards, guidelines, and BMPs appeared adequate across all harvest areas monitored. Harvest activities appeared to have little impact on soil productivity as a result.

Prescribed Fire Effects Monitoring

Following a Forest prescribed fire in 2005, mineral soil exposure was observed on less than 10% of the burn area (USDA 2005). This has been a consistent observation of other prescribed fires since 2005. Mineral soils have rarely been scorched nor have excessive amounts of the soil duff layer been consumed following a controlled burn. Prescribed fire in uplands has typically been managed at a low enough intensity, to reduce tree species mortality yet achieve fuels reduction objectives. Where complete duff consumption or mineral soil scorching has been observed, it has been primarily underneath jackpots of heavy fuels or burn piles. Jackpots and burn piles typically occur at a small enough scale in a burn area to have little impact on soil productivity.

Long-Term Soil Productivity Study

Treatment plots where soils were highly compacted showed little sign of recovery after a decade since the study began (USDA 2004c). Recovery rates were slower than what had been measured in most other study areas across the nation. The freeze thaw cycles common to Minnesota climate may not have been effective at remediating compaction (Powers et al. 2005).

All measures of aspen regeneration generally declined from reference conditions in study sites where the forest floor was removed or soils were compacted. The greatest declines occurred in sites were soils were highly compacted which also showed the least amount of recovery after 10 years. Aspen density actually increased slightly when the forest floor was removed (USDA 2004c), likely due to reduced competition with other species. Diversity of ground-flora species also increased, but species primarily consisted of those that are more adapted to colonization of disturbed habitats (Host 2005).

MFRC Site-Level Guidelines Monitoring

Three of the sites included in the Site-Level Guidelines Monitoring in 2005 were located on the Blackduck District. A summary of the results included the following:

- At all sites, skid trails and temporary roads were generally well vegetated (greater than 50% cover) and showed little signs of rutting or erosion.
- Landings were not sufficiently vegetated at any of the sites, yet little erosion or rutting was evident.
- Only one of the three sites monitored had sufficient coarse woody debris in the general harvest and riparian areas (greater than 4-5 trees per acre).

In 2009, three more CNF sites were included in the Site-Level Guidelines Monitoring, all located on the Deer River District. Data collection protocols had been refined since 2005, so slightly more information was collected at each site. A summary of the results included the following:

- The area extent of timber sale infrastructure, in all sites, was consistent with BMPs (temporary roads and log landings occupied less than 3% and skid trails occupied less than 10-15% of the total harvest area respectively).
- In all sites, skid trails, log landings, and the general harvest area were generally well vegetated and showed little signs of rutting or erosion. Portions of temporary roads in two of the three sites had insufficient vegetative cover and no erosion controls. In one instance, erosion was evident and severe as a result.
- Rutting at a crossing in one of the sites exceeded area guidelines (greater than 10% of the total area of the crossing).

Implications

Summary of Focused and Interdisciplinary Forest Plan Monitoring

Based on monitoring since 2005, past vegetation treatments on Forest lands generally appear to have had little impact on soil productivity and likely have not exceeded the R9 threshold for detrimental soil disturbance. This is an indication that it is generally doing well at implementing objectives and moving toward desired conditions in its Forest Plan, largely in part, due to effective implementation of the Forest Plan's standards, guidelines, (USDA 2004a, pp. 2-13 through 17) and BMPs (MFRC 2005).

Although past soil quality monitoring by the Forest has been grounded in current science, and followed FS policy and direction, quantitative soils monitoring will be necessary to assess the effects of forest management activities with greater confidence.

There has been little to no soils monitoring completed for forest management activities other than vegetation treatments. Soil erosion, for example, has been observed in past years on developed and dispersed recreation sites (USDA 2008).

To adequately assess progress toward meeting objectives and desired conditions of the CNF Plan, a more accurate account of current conditions and the effects of other management activities on soil productivity need to be monitored and documented.

Long-Term Soil Productivity Study

The LTSP study on the Forest indicates heavily compacted soils and excessive forest floor removal clearly have an effect on soil productivity, and it may be many years for the soils to recover (USDA 2004c). Results from the LTSP study support the need to continue soil compaction and nutrient monitoring. Soils have yet to show recovery, 10 years after severe compaction and nutrient removal.

MFRC Site-Level Guidelines Monitoring

The six CNF harvest areas monitored by the MDNR in 2005 and 2009 were generally in high compliance with most Site-Level Guidelines. Failures were found primarily with rehabilitation of log landings and temporary roads and coarse woody retention; however visual signs of soil disturbance were not evident.

Following harvest activities, there appears to be a need for greater efforts in revegetating portions of the timber sale infrastructure, particularly in areas with the greatest amount of traffic

and soil disturbance. In the future, the need to retain infrastructure should be evaluated and restoration activities considered to improve the over-all compliance with Site-Level Guidelines.

Failures in meeting the coarse woody retention guidelines, in part, may be a result of existing conditions prior to harvest. These sites should be identified in advance of final silvicultural prescriptions so that creation of large wood may be included into treatment activities.

New Issues

Exotic Earthworms

Exotic earthworms were addressed in the Forest Plan FEIS, but the effects of worms on soil productivity and vectors for earthworm expansion were not as well understood at the time of the decision.

In the absence of earthworms, decomposition of leaf litter in mixed northern hardwood forests is controlled by fungi and bacteria. In this situation, decomposition is slow and leaf litter accumulates to form a thick forest floor. A thick forest floor is where most nutrients are found and where most understory plants and tree seedlings grow and germinate. When earthworms invade, they consume the forest floor and mix it into the upper mineral soil layer. Organisms that live in the forest floor lose habitat and food and either leave to find new suitable or die trying. Without the forest floor as an insulator, the soil gets warmer in the summer and colder in the winter, making it difficult for understory plants adapted to more natural forest floor conditions to survive (GLWW 2011).

The extent of infestation on the Forest still remains uncertain, but past monitoring has provided some context. From 2005 to 2008, the Monitoring, Inventory, and Survey Team (MIST) recorded presence and extent of earthworm infestation in individual forest stands. Surveys have continued since 2008, but data is not yet available. Roughly one-third of the over 1,500 stands assessed over the four-year period had visual surface indicators of earthworm presence. They were scattered across the Forest primarily near lakeshores and within mixed northern hardwood ecosystems.

Earthworm surveys conducted by the Forest up to this point in time have suffered from a lack of funding, coordination, and training. For instance, on sites with multiple surveys, earthworm extent ratings have varied amongst different surveyors. To resolve these issues the Forest has been searching for additional funding sources and has been working to bring in experts to help train its personnel. The Forest is also starting to implement measures in its harvest and road management practices to reduce further spread of earthworms. Harvest equipment is cleaned prior to leaving some harvest units and roads not necessary for forest management have been closed or decommissioned.

Biomass Removal

Biomass removal was not specifically addressed in the Forest Plan FEIS, but it was not excluded from management consideration at the project level (USDA 2004b, p. J-418). At the time of the Forest Plan decision, there was not a significant demand for biomass and the effects of biomass removal were not as well understood as they are currently.

In response to the more recent increase in demand for biomass as an alternative fuel source, MFRC developed forest biomass harvesting BMPs that were appended to the existing BMPs in 2007. The guidelines were designed to maintain soil productivity under conditions for which additional nutrients may be removed from a site beyond what is typically removed in a conventional harvest. When BMPs are effectively applied, the nutrient capital of most Minnesota soils will be sufficient to tolerate several harvest rotations and additional biomass removal (Grigal 2004 and MFRC 2005). In light of this science, avoidance of excessive biomass removal in some pine forest ecosystems remains a BMP (MFRC 2005) and Forest Plan guideline (USDA 2004, p. 2-16).

There have been suggestions from some FS soil scientists that biomass removal from pine forest ecosystems should be encouraged in some cases rather than avoided. There is a perception that areas on the Forest have an overabundance of nutrients, beyond what would have occurred naturally, as a result of historic fire suppression and slash retention practices. Based on informal field observations, the types and abundance of vegetation give some indication that soils may be more productive than they should be; however there is no research to substantiate it. Future studies will be necessary determine if the abovementioned hypothesis is true, and if so, what effect will it have on future forest management practices.

Climate Change

Climate change was not analyzed in any great detail in the Forest Plan FEIS due to uncertainties of its effect on the environment at the time of the decision. The Forest Plan was designed to move the forest toward increased diversity, a strategy that may provide for environmental resiliency in the face of climate change (USDA 2004b, p. J-103 through 104).

Since the Forest Plan decision, climate change science and confidence in future climate change predictions and their effects on the environment have grown significantly. With greater knowledge and confidence, the Forest is better positioned to anticipate potential soil productivity impacts and prepare for possible changes in future management practices. Some examples of this may include some or all of the following:

- Predicted decreases in snow cover, increases in frost-free period, and increases in precipitation intensity and frequency of extreme storm events (IPCC 2007a) may all be factors in changing operability requirements for future timber harvests. More vigilant monitoring may be necessary to ensure soil productivity is maintained.
- A more strategic approach in defining future soil quality standards may be necessary in light of predicted changes in temperature and precipitation patterns (IPCC 2007a). Standards may need to adapt to changing conditions.
- Predicted changes in forest ecosystems that may result from a changing climate (IPCC 2007b) may alter ecological interpretations of how best to maintain native plant community complexity and resilience into the future.

Regardless of the uncertainty, soils management on the Forest will likely change to be both proactive and responsive to future climate change.

Recommendations

- Soils monitoring needs to include forest management activities other than just vegetation treatments to adequately assess how well objectives and desired conditions of the Forest Plan are being met.

- In the future, more quantitative soils monitoring will be necessary to assess the effects of forest management activities with greater confidence.
- Results from the LTSP study support the need to continue soil compaction and nutrient monitoring. Soils have yet to show recovery, 10 years after severe compaction and nutrient removal.
- Following harvest activities, there appears to be a need for greater efforts in revegetating portions of the timber sale infrastructure, particularly in areas with the greatest amount of traffic and soil disturbance. In the future, the need to retain infrastructure should be evaluated and restoration activities considered to improve the over-all compliance with Site-Level Guidelines.
- Failures in meeting the coarse woody retention guidelines, in part, may be a result of existing conditions prior to harvest. These sites should be identified in advance of final silvicultural prescriptions so that creation of large wood may be included into treatment activities
- It is highly likely that earthworms are present across the Forest. Current and past observed impacts illustrate the need for a more detailed inventory of the infestation and development of tools to reduce further risk of spread.